The parameters P and Q are strongly correlated and if Q is assumed at the values calculated in Ref. 2 ($Q = 0.019$), P would also fall very close to the value calculated there ($P = 0.055$), as can be seen interpolating the values contained in Table II.

Summarizing, the shape dependence is established in the range from 0 to 10 MeV from the context of a large amount of experimental data, and quite independently from effects attributable to corrections or assumptions made in their analysis.

It is hoped that nuclear calculations based on the detailed proton-proton interaction will abandon the use of potential shapes (or models) inconsistent with the results reported here.

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CORE EXCITATION IN Ir^{193}

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In a recent paper[1] some essential points concerning the level scheme of Ir^{193} (populated by the beta decay of Os^{193}) were clarified. The decay scheme is presented in Fig. 1.

The spin assignments for the 139-, 180-, 361-, 460-, and 712-keV states were determined as $\frac{5}{2}^+$, $\frac{3}{2}^+$, $\frac{3}{2}^+$, $\frac{3}{2}^+$, and $\frac{3}{2}^+$, respectively. The $\frac{3}{2}^+$ spin assignment for the 361-keV level showed that this level could not be identified as the $\frac{7}{2}^+$ 357-keV level. The latter level has been found to be populated by Coulomb excitation.[2] Furthermore, it was found that the 181-keV line is composed of two gamma rays and that only about one-third of the total intensity of the line de-excites the 180-keV state. It follows then that the ratio of the $M1$ reduced transition probability of the 107-keV line to that of the 180-keV transition is equal to 20. This behavior of the nucleus Ir^{193} resembles very closely that of Au^{197}. This resemblance is further displayed by the sequence of excited levels and the static moments of the states in both nuclei. The mode of de-excitation of the levels and their static moments were accounted for in Au^{197} by describing the states with particle-core wave functions.[3,4]

It was tempting to see whether a similar description of the states in Ir^{193} would account for the mode of de-excitation of the states and for their static moments. Ir^{193} lies in the intermediate region between the deformed and the spherical nuclei, and it is not clear, a priori, whether the principle of "weak coupling" is applicable for this nucleus.

In order to make a quantitative comparison between theory and experiment, we carried out lifetime measurements by the self-comparison method[5] for the most prominent states of Ir^{193} which had not been yet determined. The mean lifetimes of the 139-keV and the 460-keV states were found to be $(1.27 \pm 0.13) \times 10^{-10}$ and (2.7

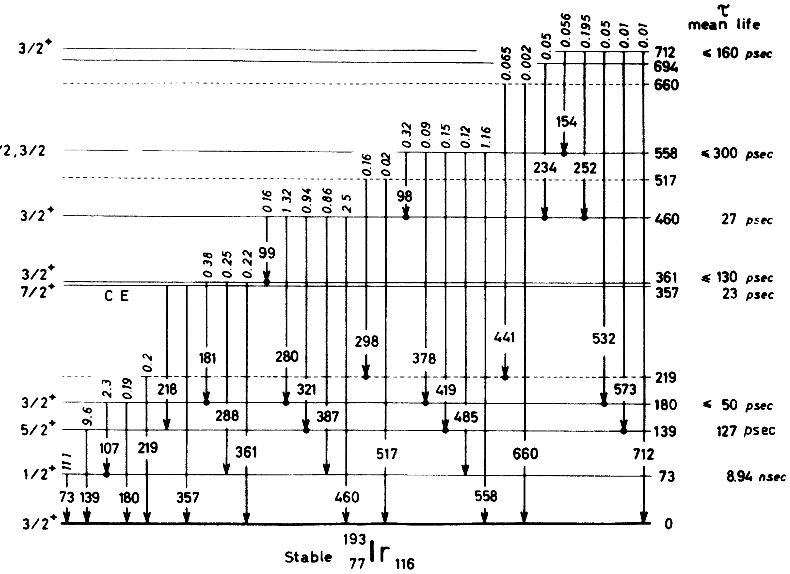

FIG. 1. The level scheme of Ir^{193} populated by the beta decay of Os^{193} taken from Ref. 1. The mean lifetime for the 357-keV state (which is populated by Coulomb excitation), and its mode of de-excitation, were taken from Ref. 2. The mean lifetime for the 73-keV level was taken from H. de Waard, Physica 20, 41 (1954), and those for the other levels, from the present work.

$\pm 0.7)\times 10^{-11}$ sec, respectively. The upper limits for the mean lifetimes of the 180-, 361-, 712-, and 558-keV levels were found to be 5×10^{-11}, 1.3×10^{-10}, 1.6×10^{-10}, and 3×10^{-10}, respectively.

Concentrating our attention on the ground state and on the 73-, 180-, 139-, and 357-keV states first, we see that with the core-excitation model we can describe the four excited levels in Ir^{193} in terms of wave functions resulting from the coupling of the $d_{3/2}$ orbit of the 77th proton to the 2^+ state of the core. In this way we get a quadruplet $\frac{1}{2}^+$, $\frac{3}{2}^+$, $\frac{5}{2}^+$, and $\frac{7}{2}^+$ corresponding to the excited states of Ir^{193}.

In order to test the core-excitation model under more stringent conditions, the 460-keV $\frac{3}{2}^+$ state was also included in the theoretical analysis by describing the state in terms of a configuration resulting from the coupling of the $s_{1/2}$ orbit of the odd proton to the 2^+ state of the core.

In order to compare theory with the experimental results, we describe the six states in Ir^{193} with a notation similar to that of Ref. 4. The 73-, 139-, and 357-keV states are described by the $|2\,\frac{3}{2},\frac{1}{2}\rangle$, $B|2\,\frac{3}{2},\frac{5}{2}\rangle+(1-B^2)^{1/2}|0\,\frac{5}{2},\frac{5}{2}\rangle$, and $|2\,\frac{5}{2},\frac{7}{2}\rangle$ wave functions, respectively, and the three $\frac{3}{2}^+$ states by the $a_{i1}|0\,\frac{3}{2},\frac{3}{2}\rangle+a_{i2}|2\,\frac{3}{2},\frac{3}{2}\rangle+a_{i3}|2\,\frac{1}{2},\frac{3}{2}\rangle$ wave functions. $|J_Cj,J\rangle$ denotes a state in which the odd proton in a state j is coupled to the core in the state J_C to give a total angular momentum J. B and a_{ik} are the amplitudes of the admixed configurations. The values of the nine amplitudes a_{ik} are restricted by six orthonormality relations. Hence the a_{ik} amplitudes are determined uniquely by three free parameters.

We get expressions for the reduced transition probabilities and the static moments similar to those of Ref. 4. In many cases, however, our expressions include additional terms due to the interfering configuration of the 460-keV state. For the reduced matrix elements $\langle\frac{3}{2}\|\Omega_p^{(1)}\|\frac{5}{2}\rangle$, $\langle\frac{3}{2}\|\Omega_p^{(2)}\|\frac{5}{2}\rangle$, and $\langle\frac{1}{2}\|\Omega_p^{(2)}\|\frac{3}{2}\rangle$ that appear in the expressions for the transition probabilities we take the single-particle estimates.[6]

An attempt was made to account theoretically for the nine $M1$ and the ten $E2$ experimental transition probabilities which correspond to all the de-excitation modes of the levels under consideration,[7] and also for the four measured[7-10] static moments. The 23 corresponding theoretical expressions were fitted by choosing the proper values for the four amplitudes, two g factors, and three matrix elements. The 23 experimental results and the corresponding predictions of this model are given in Tables I and II. The following values were taken for these nine parameters: $a_{11}=0.977$, $a_{22}=-0.973$, $a_{33}=0.96$, $B=0.954$, $g_p=0.118$, $g_C=0.575$, $\langle 0\|\Omega_C^{(2)}\|2\rangle=1$, $\langle\frac{3}{2}\|\Omega_p^{(2)}\|\frac{3}{2}\rangle=0.85$, and $\langle 2\|\Omega_C^{(2)}\|2\rangle=-0.5$.

As is clear from Tables I and II, a rather strik-

Table I. Comparison between the experimental results and the theoretical predictions for T_γ, the transition probability in sec^{-1}. E_γ is the energy of the transition in MeV, $\alpha^2=4.2\times10^{12}$ sec^{-1} MeV^{-3}, and $\beta^2=1.23\times10^{13}$ sec^{-1} MeV^{-5}. The experimental results given in this table were deduced from those of Ref. 1 and the present lifetime measurements unless otherwise indicated by a specific reference. The $E2$ admixtures of 10^{-4} and 0.2 were assumed for the 107- and 180-keV transitions, respectively.

ENERGY OF TRANSITION keV	THEORETICAL $T_\gamma(M1)/\alpha^2E_\gamma^3$	EXPERIMENTAL $T_\gamma(M1)/\alpha^2E_\gamma^3$	THEORETICAL $T_\gamma(E2)/\beta^2E_\gamma^5$	EXPERIMENTAL $T_\gamma(E2)/\beta^2E_\gamma^5$
73	0.009	0.0065 ± 0.001 [a]	0.191	0.153 ± 0.02 [a]
107	0.302	≥ 0.5	0.00126	≥ 0.0015
139	0.133	0.19 ± 0.03	0.20	0.34 ± 0.15
180	0.0152	≥ 0.016	0.12	≥ 0.047
218	0.163	0.27 ± 0.06 [b]	0.146	0.095 ± 0.05 [b]
280	0.1295	0.07 ± 0.04	0.0066	≤ 0.013
321	0.0412	0.035 ± 0.015	0.004	0.0027 ± 0.0015
357			0.201	0.30 ± 0.06 [b]
387	0.0126	0.02 ± 0.01	0.005	≤ 0.01
460	0.0286	0.029 ± 0.016	0.002	$0.012^{+0.07}_{-0.011}$

[a]Refs. 7 and 8. [b]Ref. 2.

Table II. Comparison between the experimental results and the theoretical predictions for the magnetic and the quadrupole moments. The experimental results given in this table were deduced from those of Ref. 1 and the present lifetime measurements unless otherwise indicated by a specific reference.

ENERGY OF STATE keV	THEOR. MAGN. MOMENT n.m.	EXPER. MAGN. MOMENT n.m.	THEOR. QUAD. MOMENT barn	EXPER. QUAD. MOMENT barn
0	0.15915	0.1589 ± 0.0009 [a]	0.704	1.0 ± 0.5 [d]
73	0.516	0.477 ± 0.02 [b]		
139	1.35	0.68 ± 0.11 [c]		

[a]Ref. 9.
[b]Rev. 8.
[c]Ref. 10.
[d]Ref. 11.

ing agreement is attained between the theoretical and corresponding experimental values, bearing in mind that the comparison has been made for all the available results that are connected with these six levels. In the present analysis only six levels were taken into account, and the presence of the other levels was ignored, chiefly since their modes of de-excitation were not known sufficiently well. However, the presence of these levels and their de-excitation to the six states undoubtedly indicate that the latter states must contribute additional small configuration admixtures.

The three a_{ii} values give the amplitudes of the dominant configurations in the three $\frac{3}{2}$ states. As is evident, the absolute values of the three a_{ii} and the B amplitudes are close to unity, in agreement with the basic assumptions of the core-excitation model. Here the two g factors g_p and g_c of the $d_{3/2}$ proton and the core, respectively, are close to the values corresponding to Au^{197}.

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NEUTRON CROSS SECTIONS FROM SELECTIVE REACTIONS ON DEUTERIUM*

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We consider high-energy reactions on deuterium that are selective to one type of nucleons. The strong suppression at small momentum transfers of cross sections for two identical nucleons in the final state is shown to be strongly dependent on the spin nature of the reaction. Recent data on π^+ photoproduction on deuterium are reproduced.

Deuterium targets are widely used in high-energy reactions as a source of information on neutron cross sections. The analysis of the data is usually based on the spectator model modified to include the Glauber corrections.[1] In reactions where the deuteron target is transformed into two identical nucleons Glauber and Franco,[2] neglecting spin effects, predicted a vanishing deuteron cross section at zero momentum transfer due to the Pauli exclusion principle. However, recent data[3] on high-energy π^+ photoproduction on deuterium show a suppression of only about 40% at small momentum transfers, relative to π^+ photoproduction on hydrogen (see Fig. 1). This discrepancy does not imply the breakdown of the modified spectator model. Rather, we would like to point out that a full account of the Pauli exclusion principle together with spin effects is essential for maintaining that model. In this note simple prescriptions are derived that relate high-energy deuteron cross sections to nucleon cross sections for reactions which are selective to one type of nucleons. In particular, the strong suppression at small momentum transfers, and its spin dependence, is evaluated and the photoproduction data mentioned above are reproduced. It is found that shadow effects do not necessarily reduce the deuteron cross section relative to that of a single nucleon.

Consider the selective reaction

$$m_i + d \to m_f + 2p, \tag{1}$$

where m_i and m_f are the incident particle (meson or photon) and the produced one, respectively. The reaction amplitude in a certain helicity configuration of the initial and final particles is constructed in the diffraction approximation[1] from the amplitude $g(\vec{q})$ (a matrix in spin space) for reaction on a single neutron n, preceded or followed by elastic scattering [described by a scattering matrix $f(\vec{q})$] on the spectator proton:

$$F_{i\to f}(\vec{q}) = \sqrt{2}\langle\Psi_{2p}|\frac{k}{2\pi}\int e^{i\vec{q}\cdot\vec{b}}\Gamma_i(\vec{b}-\vec{b}_p;z_p,z_n)\tilde{g}(\vec{b}-\vec{b}_n)\Gamma_f(\vec{b}-\vec{b}_p;z_n,z_p)d^2b|\Psi_d\rangle, \tag{2}$$

where k is the c.m. momentum and $\vec{q}$ is the transverse component of the momentum transfer. Indices like p and n refer to the coordinates, measured from the nuclear center of mass, of the spectator and